UNIVERSITI PUTRA MALAYSIA

THE EFFECTS OF ANGULARITY NUMBER ON TEXTURE DEPTHS AND SKID RESISTANCE OF STONE MASTIC ASPHALT

MOHTADY ALI MUSA

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By

MOHTADY ALI MUSA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March 2002

Dedicated to my beloved family:

Father; may Allah send his mercy on his grave,

Mother, Brothers, Brother-in-law, and Sisters

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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MOHTADY ALI MUSA NORELDIEN

March 2002

Chairman : Professor Ir. Dr. Radin Umar Radin Sohadi

Faculty : Engineering

Skidding of vehicles due to the lack of friction between pavement and tires, especially on wet pavements, is a problem to road users. There are many parameters that can help in attaining higher friction of pavement to control skidding such as microtexture and macrotexture of stones. One of the controlling parameters for macrotexture is the shape of stones for pavement construction. This research examines the angularity and related characteristics of aggregates for the formulation of high friction stone mastic asphalt wearing course.

In this study, only a small range of aggregate angularities could be produced using a UPM crushing machine. Hence, attempts to produce a wider range of angularities were aborted. Out of eighty one quarries investigated, only eight quarries were found suitable for this study. This is because of their different crushing systems which produce a wide range of angularities.

The collected aggregate materials were analysed for their Angularity Number and the Particle Shape Index as well as the other physical properties including petrography study. These aggregate materials were then mixed with the optimum content of 60-70 penetration grade asphalt cement as determined by the UPM in-house method of mix design. A total of one hundred and twenty samples were then casted. These samples were examined for their density, resilient modulus, and voids. The performance tests namely, Marshal stability, flow, static and dynamic creep modulus, and indirect tensile strength test were carried out. Regression analysis was done to correlate the aggregate Angularity Number with the stability, resilient modulus, density, Voids in Total Mix (VTM), Voids in Mineral Aggregate (VMA), static recovery efficiency and Surface Area (SA) using Microsoft EXCEL. The correlation was determined according to the value of the coefficient of regression. The result of the regression showed that there is a significant correlation of the density, VTM, VMA and SA with the Angularity Number.

Slab samples of size 0.43m x 0.43m x 0.043m were prepared from the different crushed quarry aggregates. The British Pendulum Number (BPN) and the Texture Depth (TD) were determined using the British portable skid tester and the sand patch methods, respectively. The regression analysis was performed to correlate the BPN with AN, SA, VMA and TD and to correlate VTM, TD and density with AN. The results of the regression showed that there is a correlation of skid resistance with AN, VMA, and also there is a correlation between TD and AN (R^2= 0.67).

Finally, Stepwise, Forward and Backward regression methods were performed, using statistical analysis software MINITAB. This was used to predict the relationship between skid resistance and the physical parameters of the aggregate and the performance characteristic of the mix, such as Angularity Number, Polished Stone Value, Particle Shape Index, Flakiness, Texture Depth, Voids in Total Mix and Voids in mineral aggregate. The best model with the highest regression coefficient $R^2 = 0.87$ was selected, using the backward regression method. This model is highly recommended to predict a high friction wearing course.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

KESAN NOMBOR KESISIAN KE ATAS KEDALAMAN TEKSTUR DAN RINTANGAN GELINCIRAN STONE MASTIC ASPHALT

Oleh

MOHTADY ALI MUSA NORELDIEN

Mac 2002

Pengerusi : Professor Ir. Dr. Radin Umar Radin Sohadi

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Kemalangan terbabas dan tergelincir akibat kurangnya daya cengkaman antara tayar dan permukaan jalan terutamanya pada permukaan turapan yang basah adalah merupakan antara masalah utama kepada pengguna jalan raya. Kajian ini memeriksa parameter utama yang boleh membantu menghasilkan geseran yang tinggi pada turapan bagi mengawal gelinciran. Dua parameter yang dikenalpasti adalah mikrotekstur dan makrotekstur batuan. Salah satu faktor yang mengawal parameter makrotekstur adalah bentuk batuan yang digunakan dalam kerja-kerja turapan.

Dalam kajian ini hanya batuan dengan kesisian kecil boleh dihasilkan dengan menggunakan Mesin Penghancur UPM. Namun begitu, segala usaha untuk menghasilkan ketetapan kesisian secara meluas tidak berjaya dilakukan. Daripada lapan puluh satu kuari yang dikaji didapati hanya lapan kuari sesuai bagi kajian ini. Ini adalah kerana sistem pemecahan batuan yang berbeza menghasilkan julat

kesisian yang tinggi. Batuan-batuan yang dikumpulkan diuji bagi Nombor Kesisian (AN) dan Indeks Bentuk (PI) di samping ujian sifat-sifat fizikal dan petrografi. Batuan-batuan tersebut kemudian dicampurkan dengan asfalt optimum bergred penusukan 60-70 mengikut kaedah campuran UPM di makmal.

Sejumlah seratus dua puluh sampel disediakan dan diuji bagi ketumpatan, modulus keanjalan dan analisis rongga. Selain itu, ujian Marshall dan pengaliran, ujian rayapan statik dan dinamik dan kekuatan modulus tegangan juga dijalankan. Analisis regresi digunakan bagi menghubungkait Nombor Kesisian dengan kestabilan, modulus keanjalan, ketumpatan, rongga dalam campuran, rongga dalam asfalt, kecekapan kembalian statik dan ujian luas permukaan dengan menggunakan perisisan EXCEL. Hubungkait tersebut bergantung kepada pembolehubah regresi. Hasil daripada analisis regresi membuktikan memang terdapat hubungan yang bererti bagi Nombor Kesisian dengan ketumpatan, rongga dalam campuran, rongga dalam asfalt dan luas permukaan.

Sampel papak (0.43m x 0.43m x 0.043m) juga disediakan untuk ujian Nombor Pendulum British dan ujian kedalaman tekstur. Kajian ini dilakukan dengan menggunakan Penguji Rintangan Gelinciran Pendulum British dan kaedah tampalan pasir. Analisis regresi dijalankan bagi menghubungkaitkan Rintangan Gelinciran dengan Nombor Kesisian, luas permukaan, rongga dalam mineral batuan dan kedalaman tekstur. Selain itu, analisa regresi ini juga mengaitkan Nombor Kesisian

dengan rongga dalam campuran, kedalaman tekstur dan ketumpatan. Hasil daripada analisis regresi menunjukkan terdapat hubungan antara rintangan gelinciran dengan Nombor Kesisian, rongga dalam mineral batuan dan terdapat hubungkait antara ujian Nombor Kesisian dan ujian kedalaman tekstur (R^2=0.67).

Selain itu, analisis regresi kaedah kehadapan dan kebelakang telah dijalankan dengan menggunakan perisian MINITAB. Analisis statistik ini adalah untuk menjangka hubungan antara cengkaman dengan parameter fizikal bagi campuran. (Nombor Kesisian, rongga dalam campuran, Nilai Kelicinan Batuan, Indeks Bentuk, Keleperan, Kedalam Teksur, rongga dalam mineral batuan). Model terbaik dengan pembolehubah regresi (R^2 = 0.87) dipilih hasil daripada ujian regresi kebelakang. Model ini adalah dicadangkan untuk menjangkakan lapisan haus bercengkaman tinggi.

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Last but not least, I extend my deepest gratitude and thanks to my mother, brothers and sisters for their support, patience and encouragement. Without their help and encouragement I would never have finished this valuable undertaking.

I certify that an Examination Committee met on 9th March 2002 to conduct the final examination of Mohtady Ali Musa Noreldien on his Master of Science thesis entitled "The Effects of Angularity Number on Texture Depths and Skid Resistance of Stone Mastic Asphalt" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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Date: 13 JUN 2002

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

MOHTADY ALI MUSA

Date: 02 MAY 2002

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES